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A PLAN TO IDENTIFY AND ASSESS EMISSION REDUCTION OPPORTUNITIES FROM TRANSPORTATION, INDUSTRIAL ENGINES AND MOTOR FUELS

Transport Canada Transports Canada

Environment Canada Environnement Canada

A
PLAN
TO
IDENTIFY AND ASSESS
EMISSION REDUCTION OPPORTUNITIES
FROM
TRANSPORTATION, INDUSTRIAL ENGINES AND MOTOR FUELS

(AUSSI DISPONIBLE EN FRANÇAIS)

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1. PURPOSE:

The purpose of this plan is to identify and assess opportunities to reduce emissions associated with the use of internal combustion (IC) engines and the fuels that power those engines.

The plan will focus on emission reductions possible from:

a) transportation motor vehicles
   - road motor vehicles (motorcycles, passenger cars, light trucks, heavy trucks, and buses)
   - aircraft
   - rail locomotives
   - marine vessels;

b) industrial equipment used in
   - construction
   - agriculture
   - forestry
   - mining
   - miscellaneous applications incorporating IC engines; and

c) motor fuel production, distribution, marketing, and use.

This plan is intended to support efforts by the Government of Canada to protect the health of Canadians and the environment from damage caused by pollution by providing technical information and facilitating consultation with all interested parties. The results of these activities will be used in making decisions on future emission control actions.

2. PREPARATION OF THE PLAN:

This plan has been prepared jointly by Transport Canada and Environment Canada in consultation with other federal departments which have a direct interest or involvement in the work covered by the plan.

Data presented in this plan should not be viewed in an absolute sense. They are intended to give perspective to the plan for the purpose of stimulating discussion and the exchange of information between all interested parties. The data are based on the best information that is available today. Refinements, changes, and additions to improve and to fill gaps in the current knowledge base will result as the plan proceeds.

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3. INTRODUCTION:

Since the late 1960's Canada has supported the principle that damage to the most sensitive portion of our environment should trigger actions to reduce pollution. Under the Clean Air Act, National Ambient Air Quality Objectives (NAAQOs) for sulphur dioxide, suspended particulates, ozone, carbon monoxide and nitrogen dioxide were set in order to protect the health of Canadians living in cities. For the NAAQOs set under the Clean Air Act, there are some exceedances of established maximum acceptable levels of pollution. The most frequent NAAQO exceeded is that for ozone. Exceedances of the maximum acceptable level of ozone pollution occur across Canada most often in the Greater Vancouver Regional District, in the Windsor to Quebec City corridor and in portions of the Maritimes.

Under the definitions and provisions of the Canadian Environmental Protection Act, existing NAAQOs are retained. Ambient air quality objectives for additional pollutants, substances and industrial compounds will be investigated in work separate from this plan to determine if their use and release into the environment needs to be controlled.

4. FUEL USE BY IC ENGINES:

The use of fossil fuels to power internal combustion engines and equipment for transportation and industrial purposes is responsible for a major portion of the air pollution produced in Canada. The pollutants of concern include carbon dioxide, carbon monoxide, oxides of nitrogen, diesel particulates, and a variety of unburned or incompletely burned hydrocarbons. These pollutants contribute in a material way to the major environmental issues of concern today in Canada and in other countries.

5. ENVIRONMENTAL ISSUES:

Air pollution can be defined as the presence in the atmosphere of pollutants. Pollutants are substances (gaseous or particulate) or mixtures of substances, which produce a measurable adverse effect on man, animals, vegetation, or materials. Air quality is poor if the concentration of a pollutant (or pollutants) in air exceeds the level at which it is considered to have an adverse effect.

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In recent years, this definition of air pollution has been broadened to include atmospheric effects on a global scale. Global changes in the atmosphere include the destruction of the stratospheric ozone layer and the increase in gases which contribute to the greenhouse effect. This broader definition of air pollution now includes substances which were previously considered to be benign such as chlorofluorocarbons (CFC's) and carbon dioxide.

Air pollutants can result from both natural and man-made sources. For example, hydrocarbons are emitted from vegetation. Oxides of nitrogen are emitted from soil and are produced by lightning. Carbon monoxide is formed from oxidation of methane which is produced by natural sources. Air pollution control strategies must take into account the relative contribution of natural and man-made emissions; but, in practical terms, emission reductions can be achieved only by controlling man-made sources.

There are two basic categories of air pollutants: primary and secondary. Primary pollutants, such as nitrogen oxides, carbon monoxide, and hydrocarbons, are released directly into the air from fuel combustion in stationary and mobile sources or from other processes. However, under the proper conditions, some of these primary pollutants can undergo chemical reactions and transformations in the atmosphere to produce secondary pollutants, such as ozone and nitric acid. Primary pollutants acting in this way are often referred to as precursor emissions.

The major Canadian environmental issues which are associated with the use of IC engines and motor fuels and are addressed by this plan include climate change; depletion of the stratospheric ozone layer; acid deposition; ground-level photochemical oxidants; and the exposure of the Canadian population to a variety of toxic air pollutants. A brief description of each issue follows.

a) Climate Change - Global Warming

i) Planet Earth: A Natural Greenhouse

The sun heats the earth, providing the warmth and energy necessary to sustain life on our planet. But the heating of the earth is not as simple as one might first assume. Certain gases in the atmosphere act somewhat like a blanket, keeping the surface of the earth warm.

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Without these atmospheric gases, the surface of the earth could be as barren and cold as the surface of the moon. This effect is similar in some ways to the glass in a greenhouse. The sun's rays pass through the atmosphere to the earth's surface, which heats up and radiates heat energy back to space. Some of this radiated heat energy is captured by atmospheric "greenhouse" gases, such as carbon dioxide, and partly returned to earth, thus "trapping" heat close to the surface.

ii) Turning up the Thermostat

Human activities have significantly increased the amount of carbon dioxide and other "greenhouse gases" in the atmosphere. These gases are expected to add to the natural greenhouse effect and substantially alter global climate. The climate changes that are possible in the near future could exceed anything experienced in human history.

Studies of future climate, based on complex computer calculations, indicate that average world temperatures could increase between 1.5 and 4.5 C° if global carbon dioxide is doubled. This could take place between the middle and the end of the 21st century, depending on future energy use. Warming would be 2-3 times greater in the arctic regions than in the tropics, causing a change in global heat distribution. Major alterations in global wind patterns and rainfall distribution would result. A generally dryer climate is predicted for mid-latitude areas, such as southern Canada, while increased moisture is expected in the arctic regions and possibly in the tropics. Global sea levels may rise as much as one metre. Studies of climate changes in past eras tend to support these conclusions.

Although carbon dioxide is the major concern at this time, it is not the only concern. Recent studies have shown that up to 20 other atmospheric gases contribute to the greenhouse effect. The most significant of these are chlorofluorocarbons (CFCs), methane, nitrous oxide and ozone, all of which are increasing rapidly due to human activities.

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Although these other greenhouse gases are not nearly as abundant as carbon dioxide, their combined effect on the increase of the earth's temperature is expected to be almost equal to that of CO_2. This will accelerate the anticipated climatic changes, bringing the possibility of major effects within the next 50 years.

iii) Carbon Dioxide (CO_2)

Scientific measurements of atmospheric CO_2 reveal an unmistakable, world-wide increase that is rapid and escalating. Concentrations are presently rising at a rate of 3-4% per decade and are believed to have already increased by about 25% in the past 200 years. The primary cause is the rapid rise in the use of oil, gas and coal to satisfy the energy demands of today's society. At present, the worldwide burning of these fossil fuels releases close to 5 billion tonnes (400 million tonnes in Canada) of carbon, as gaseous carbon dioxide, into the atmosphere each year.

Global deforestation adds to the increase in atmospheric CO_2. Carbon dioxide in the atmosphere is part of a natural cycle. Plants and animals release CO_2 as they breathe. Decaying organic matter, volcanoes, and forest and grass fires also contribute to the CO_2 in the atmosphere. However, these natural sources are kept in balance by processes which remove the gas from the atmosphere. One such important process is photosynthesis, by which forests and other vegetation remove CO_2 from the atmosphere and store it as carbon in their tissues and wood fibres. In tropical areas, huge tracts of forest are burned to clear the land for development. Such burning suddenly releases vast quantities of carbon that have been stored in the trees for many years and destroys a natural sink for atmospheric CO_2 in the process. Estimates suggest that deforestation may be adding as much as 1-2 billion tonnes of additional carbon to the atmosphere each year.

The ocean also plays a major role in the balance of CO_2 in the atmosphere. It serves as a huge reservoir for carbon, acting both to absorb and release large amounts of carbon dioxide. However, these mechanisms are extremely complex and still poorly understood.

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The ocean and other components of the ecosystem currently remove approximately one half of the excess CO_2 released into the atmosphere by human activities. The increase in global atmospheric CO_2 is caused by the half that remains.

iv) CFCs

A group of industrial chemicals, known as CFCs (chlorofluorocarbons or freon gases), are also major contributors to the greenhouse effect. Although CFCs are far less abundant than CO_2 their effect on climate, molecule for molecule, is about 10,000 times more powerful than that of CO_2.

The amount of CFCs in the atmosphere has increased sharply in recent years, as their industrial use grows. CFCs are used as the blowing agent in the manufacture of foam insulation and padding, as spray can propellants, as coolants in refrigerators and air conditioners, and as solvents for cleaning microchips and other electronic equipment.

Since the early 1970s, CFCs have received considerable attention because of their threat to the ozone layer in the upper atmosphere. This layer protects life on earth from the harmful effects of the sun's ultraviolet rays. As a result, certain countries including Canada and the United States, introduced restrictions on the use of these chemicals in spray cans in the late 1970s.

However, the reduction in CFC use caused by this action was quickly offset by increases in non-propellant uses. By the early 1980s, global levels of CFCs in the atmosphere were increasing at an alarming rate of 5-6% per year.

In September 1987, an international agreement to reduce global levels of CFCs was signed in Montreal. This agreement will protect the stratospheric ozone layer and reduce emissions of a greenhouse gas.

v) Methane (CH_4)

Methane is a naturally-occurring greenhouse gas which has increased sharply due to human activities. In fact, the increase of global methane has virtually kept pace with the rise of world population.

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Methane gas can be produced through a variety of processes, generally involving the break-down of vegetation, either through burning, digestion or rotting without the presence of oxygen. Large quantities of methane are believed to be released by rice paddies, where vegetation rots in the water-logged soils. Cattle and other grazing livestock are also another major source, where methane is produced in the animal's digestive system. It is estimated that the large global cattle population and increasing land areas covered by rice paddies now account for almost 50% of the global release of methane.

About 20% of the global methane is produced by the burning of wood and other vegetation. Wood is burned extensively as a fuel and for industrial use in the third world. Large tracts of tropical forests are burned to clear land for agriculture.

Lesser amounts of methane are produced by the mining of coal and natural gas, which releases the methane gas trapped with these deposits. Natural sources, such as swamps and marshes, also contribute small amounts of this gas.

vi) Nitrous Oxide (N_2O)

Like methane, nitrous oxide is also a naturally-occurring greenhouse gas which has increased significantly in recent years due to human activities. At present, roughly 1/3 of the global atmospheric nitrous oxide is of human origin, resulting mainly from the use of chemical fertilizers and the burning of fossil fuels.

Nitrous oxide is produced naturally by microbes in the soil and bodies of water. The nitrogen in this gas acts as a natural fertilizer, encouraging plant growth. The agricultural industry produces large quantities of chemical nitrogen for use as fertilizers. Once added to the soil, some of this nitrogen is converted to nitrous oxide and released into the atmosphere.

The burning of fossil fuels and wood also releases large amounts of nitrous oxide into the atmosphere. The burning of wood for fuel and to clear forests for agriculture occurs primarily in the tropics, while fossil fuel combustion is characteristic of more industrialized areas.

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vii) Ozone (O_3)

Ozone is formed as a result of the energy of the sun's rays breaking up and reforming various atmospheric gases. Ozone, which is a specialized form of oxygen, is of great benefit in the upper atmosphere (stratosphere), where it shields us from the harmful ultraviolet rays of the sun. This stratospheric level ozone is formed primarily from naturally-occurring chemicals.

However, in the lower atmosphere, ozone can be a major component of urban smog - damaging crops and aggravating respiratory problems. This ground-level ozone is formed primarily by chemical reactions among a variety of air pollutants. In addition to its direct effect on plant life and health, ozone is also a powerful greenhouse gas.

b) Depletion of the Stratospheric (High Altitude) Ozone Layer

There is widespread concern that industrial chemicals have now reached even the upper layers of the earth's atmosphere and are threatening the planet's fragile ozone layer - a layer of gases that protects us from the damaging ultraviolet rays of the sun. Exposure to ultraviolet radiation can cause skin cancer, reduce crop yields and damage aquatic life. Indeed, serious depletion of the ozone layer could affect most life on earth.

Even small changes in the ozone layer can have significant impacts. Studies show that a 1% depletion in the ozone layer would result in about a 4% increase in non-melanoma skin cancer. Although this form of skin cancer is rarely life-threatening, it can be highly unsightly. Scientists strongly suspect that an increase would also occur in malignant melanoma - a rarer but often fatal form of skin cancer. Ultraviolet radiation can also cause skin and eye aging and suppress the human immune system, leading to greater susceptibility to disease.

Many agricultural crops are particularly sensitive to ultraviolet radiation, including most of the world's major food sources: wheat, rice, corn and soya beans. Although much research remains to be done, preliminary studies on soya beans indicate that a 1% depletion of the ozone layer would result in a 1% reduction in crop yield.

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Aquatic life near the ocean's surface is also very susceptible to ultraviolet radiation, and excessive exposure could disrupt fish production. Even industrial materials, such as plastics and paints, have been shown to be affected, becoming yellow and brittle with lengthy exposure.

In recent years, scientific attention has focused on ominous changes in the ozone layer. Over the past decade, the global ozone layer appears to have been slowly depleting. Measurements taken over Toronto, for example, show a decrease of 4% since 1975. However, it was the discovery of a sudden unexplained "hole" in the ozone layer over Antarctica that galvanized scientific interest. Here the ozone layer has been observed to thin dramatically during the spring over an area the size of the continental United States. Environment Canada scientists have found a similar thinning of the ozone layer over the Canadian Arctic.

Scientists do not fully understand these changes in the ozone layer but they are concerned that they could indicate a serious weakening in the earth's protective shield. Although some changes in the ozone layer could be due to natural conditions, increasing evidence now points to chemical contamination from our industrialized society as the root cause.

c) Acid Deposition

Acid rain is a serious environmental problem for Canada today. It is caused primarily by emissions of sulphur dioxide (SO_2) and nitrogen oxides (NO_x). Once released into the atmosphere, these substances can be carried long distances by the prevailing winds, and return to earth in acidic forms as rain, snow, fog or dust. When the environment cannot neutralize the acid being deposited, damage occurs.

The main sources of SO_2 emissions in North America are coal-fired power generating stations and non-ferrous ore smelters. Internal combustion engines and the fuels they use account for only 2 to 3% of SO_2 emissions. The main sources of NO_x emissions, however, are vehicles and fuel combustion.

Acid rain is causing serious economic, social, and environmental problems in eastern Canada. It is increasing the acidity of lakes and streams to the point where aquatic life is depleted, and it is increasing the acidity of soil, water, and shallow ground water. Acid rain is also

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suspected of being one of the causes of forest decline. The effects of acid rain are not limited to the natural environment; it erodes buildings and monuments, and is also suspected of contributing to respiratory problems in humans.

More than 300,000 lakes are vulnerable; approximately 150,000 are being damaged; and more than 14,000 are acidified. In addition, 19 salmon rivers no longer support the species. Eighty-four percent of the most productive agricultural lands in eastern Canada annually receive more than the acceptable levels of acid deposition.

About 55% of eastern Canada's forests, which generate $14 billion worth of forest products, are in areas where rainfall is acidic.

d) Photochemical Oxidants

Photochemical oxidants (sometimes referred to as photochemical smog) are secondary pollutants formed from the interaction of emissions of volatile organic compounds (VOC) and nitrogen oxides (NO_x) in the presence of sunlight. Ozone, one of the photochemical oxidants, has been observed to cause a variety of detrimental effects varying in severity with concentration. Ozone causes lung function changes in humans, produces toxic effects in vegetation resulting in crop yield reductions and exerts stress on forest ecosystems. Oxidants also contribute to visibility reduction and damage materials such as textiles, dyes, rubbers and plastics.

Analyses of Canadian air quality data show that ozone concentrations regularly exceed the federal maximum acceptable air quality level. Ozone at these concentrations is above the threshold level which has adverse effects on human health, crops and forests. While the maximum acceptable level has been exceeded in all major metropolitan areas, the exceedances occur most frequently in the Vancouver-Fraser Valley area and in the Windsor-Quebec City corridor. Within these areas, forty-five percent of Canada's population reside and the commercial value of ozone-sensitive crops exceeds two billion dollars. Studies show that the Vancouver ozone problem is a result of local emissions while the Windsor-Quebec City corridor ozone impacts are due to a combination of long range transport from the United States plus domestic precursor emissions. Furthermore, current scientific evidence, in combination

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with an analysis of ozone episodes in the two regions, indicates that natural ozone sources are not a major contributor to elevated ozone concentrations.

Quantitative relationships between precursor emission reductions and ozone concentrations are not yet available for Canada. However, it appears that major reductions in both No_x and VOC emissions will be required to reduce ozone impacts on health and on crop productivity. For eastern Canada, negotiated reductions in long range transport of ozone and precursors from the United States will also be needed.

Based on measured concentrations and known effects of oxidants, there is great cause for concern regarding their impacts on the Canadian public and on the Canadian economy.

e) Other Toxic Air Pollutants

The new Canadian Environmental Protection Act (CEPA) is intended, among other things, to better control toxic air pollutants in Canada in order to protect human health and the environment. CEPA provides a systematic and comprehensive approach to controlling toxic substances. Under CEPA, a list of toxic substances known as the Priority Substances List is being compiled to identify those substances requiring thorough assessment and possible control. The transportation sector is a major source of the following substances on the CEPA Priority Substances List: benzene, methyl tertiary butyl ether (MTBE), polycyclic aromatic hydrocarbons (PAH's), toluene and xylene.

In addition, there are a number of other pollutants of concern from mobile sources which are not on the Priority Substances List at this time. Two of these are aldehydes and diesel particulates.

The following is a brief description of these pollutants, the control of which will be studied under this plan.

i) Benzene

Benzene, is a volatile organic hydrocarbon which is produced from petroleum, coal and natural gas. It is a human carcinogen and has been detected in the

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environment. Benzene production falls in the top five among industrial organic chemicals. The major sources of benzene in the Canadian environment are the combustion of gasoline, the production of chemicals using benzene as a feedstock, and refinery operations. Motor vehicles are the largest single source of atmospheric benzene emissions. Benzene emissions have declined in recent years due to an increase in the use of catalytic converters and better control of evaporative emissions from motor vehicles. Further reductions are possible by controlling the benzene content of gasoline.

ii) Methyl Tertiary Butyl Ether (MTBE)

Methyl tertiary butyl ether is not produced in Canada but is imported from the United States and used in commercial gasolines to replace lead as an octane enhancer. Humans are exposed to MTBE through air emissions resulting from gasoline use, transportation, and distribution, and through groundwater contamination from leaking underground gasoline storage tanks. Chronic health effects of MTBE and exposure of Canadians to MTBE will be investigated.

iii) Polycyclic Aromatic Hydrocarbons (PAHs)

Polycyclic aromatic hydrocarbons comprise a class of complex organic compounds which include a number of known and/or suspected human carcinogens. The major sources of PAHs in the Canadian environment are the incomplete combustion of wood and fossil fuels, aluminum production, metallurgical coke production and petroleum based products. PAHs have also been found in the particulate emissions from diesel engines.

iv) Toluene

Toluene, a volatile aromatic hydrocarbon produced from petroleum and coal, is principally used as an octane enhancer in gasoline; in the manufacture of benzene; in the production of phenol; and as a solvent. The primary man-made sources of toluene in the Canadian environment are motor vehicle emissions, gasoline marketing and chemical processes using toluene. It is suspected of causing neurological damage in humans as well as damage to the liver and kidneys.

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v) Xylenes

Xylenes, a mixture of dimethylbenzene isomers, are aromatic hydrocarbons produced in large quantities from petroleum and coal. The major sources of xylenes in the Canadian environment arise from their use as octane enhancers in gasoline and as solvents. Occupational exposure has resulted in behavioural and central nervous system disorders in humans. Respiratory irritation, gastrointestinal disturbances and narcosis have been observed in confirmed cases of xylene intoxication.

vi) Aldehydes

Aldehydes are produced by all internal combustion engines as a result of incomplete combustion of the fuel. They are not a component of evaporative emissions. Formaldehyde is the most prevalent aldehyde in vehicle exhaust and is of interest because of its photochemical activity, its acute effect on health at high concentrations and its suspected carcinogenicity. Engines using methanol fuel are of concern because formaldehyde is a much larger fraction of the hydrocarbon emissions from these engines than from gasoline or diesel-fuelled engines.

vii) Diesel Particulates

Diesel engines emit particulates at a rate of 50 to 80 times that of their gasoline-fuelled counterparts. The particles are of respirable size (0.1 to 2 mm diameter) and are capable of penetrating deep into the lungs. As well, diesel particulates can absorb known carcinogens such as benzo(a)pyrene and PAHs. Consequently, the major cause for concern regarding these emissions relates to their contribution to morbidity and mortality from chronic lung disease and possible role in causing cancer.

This list of toxic air pollutants is by no means complete but serves as a general overview of the pollutants of concern that come from internal combustion engines and the fuels that they use.

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6. CANADIAN ACTIONS:

Protecting the health of Canadians and the environment is a priority of the Government of Canada. Actions taken to this end in recent years include:

a) Montreal Protocol

An international treaty was signed in Montreal, on September 16, 1987 to control substances which deplete the earth's ozone layer. The Montreal Protocol is the first international agreement aimed at protecting the atmosphere (and more precisely the ozone layer).

The Montreal Protocol sets out a short and a long term schedule to control all substances that deplete the ozone layer. In the short term, it establishes phase-down requirements to reduce emissions of specified ozone-depleting substances. In the long term, it establishes a flexible mechanism by which control measures can be periodically assessed and adjusted to reflect the latest scientific findings. The protocol requires a 50 percent reduction in the use of CFCs by 1999.

Environment Canada has a comprehensive plan that will reduce CFCs to a greater extent than that required by the Montreal Protocol. The long term goal is to completely eliminate the use of CFCs.

b) Canadian Environmental Protection Act (CEPA)

In May, 1988, the House of Commons passed the Canadian Environmental Protection Act.

CEPA contains the toughest sanctions against polluters ever enshrined in Canadian environmental law, including one million dollar per day fines and jail terms for corporate offenders. The new law is backed by a tough enforcement and compliance program, for which the government has approved $37 million in new funds.

The law will be enforced by the federal and provincial governments acting in partnership through agreements that will ensure an equivalent level of protection for all Canadians, no matter where they reside in the country.

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CEPA consolidates much of the legislative authority of the Minister of the Environment. It establishes a comprehensive system for managing toxic chemicals throughout their life cycle, from development to production, transport, use, storage and disposal.

CEPA is the product of four years of intensive consultation, involving thousands of people in every province and territory. It is, in the fullest sense, legislation made by Canadians for the benefit of Canada's environment and its people.

c) Toronto Conference on Climate Change

Canada hosted the Toronto Conference on Climate Change from June 27-30, 1988. The conference focused on the increase in CO_2 and other gases which can increase global temperature. The conference called for a 20 percent cut in CO_2 emissions by 2005.

d) Sulphur Dioxide Protocol

Canada signed an international protocol calling for a 30 percent reduction in sulphur dioxide emissions by 1993. The federal government and the 7 most eastern provinces have agreed to a comprehensive sulphur dioxide control program which will reduce SO_2 emissions by 50 percent by 1994.

e) Oxides of Nitrogen Protocol

The federal government has signed an international protocol to limit NO_x emissions to the 1987 level by December 31, 1994. Further reductions may be necessary depending on the need to achieve deposition rates below internationally established environmental quality targets.

f) International Activities

Canada is participating in activities of the Economic Commission for Europe (ECE) and the Organization for Economic Cooperation and Development (OECD) to develop environmental targets or critical loads for emissions or deposition of harmful air pollutants.

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g) Motor Vehicle Emission Standards

The federal government has imposed stringent emission standards on both light and heavy-duty motor vehicles under the Motor Vehicle Safety Act. Light-duty vehicle standards took effect on September 1, 1987 while heavy-duty vehicle standards went into effect December 1, 1988. These are among the toughest standards anywhere in the world.

h) Federal/Provincial NO_x and VOC Control Plan

In October 1988, federal and provincial environment Ministers instructed the Federal/Provincial Long Range Transport of Air Pollutants (LRTAP) Steering Committee to develop a comprehensive plan to further manage NO_x and VOC emissions in Canada. The LRTAP plan is to be designed in such a way that Canada can meet its own domestic environmental protection requirements as well as international obligations. The Ministers noted that further improvements in energy productivity and conservation should be a key feature in the plan of action. They also agreed that the issue of fuel volatility should be addressed in the development of the national plan of action. NO_x and VOC emission reductions from the sources and initiatives being considered in this plan will support the LRTAP efforts.

7. CANADIAN APPROACH TO ENVIRONMENTAL PROTECTION:

Canada has adhered to several key principles in the development of domestic control programs and in its participation in international protocols for pollution abatement. These include:

- Ensuring that environmental degradation does not occur.

- Endorsing the use of best available technology economically achievable (BATEA) to control pollution from major sources. BATEA is defined as a technology that has been commercially demonstrated somewhere in the world and which can be applied without causing unbearable economic hardship to the source of emission.

- Promoting pollution control actions to achieve environmental quality levels as dictated by the most sensitive part of the environment.

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- Accepting the need for sustainable development.

Canada has taken a leadership role internationally in promoting these principles of environmental protection. This plan supports the leadership role taken by the Canadian Government and is designed to allow Canada to fulfill its national and international obligations for emission control through to the end of the 1990s.

8. EMISSION INVENTORIES:

The emission inventories were compiled using provincially and federally developed emission data which are based on a combination of measured values and calculated estimates. The information presented represents the current state of knowledge based on available data. It is expected that the state of knowledge and emissions modelling techniques will improve during the course of this project. This will result in better estimates of emission inventories in Canada.

For the purposes of this plan, the emission inventories should be viewed as a good indication of the relative roles of major emission sources to contributions of pollutants to emission inventories in Canada. These contributions are summarized in Table 1.

a) Non-Methane Hydrocarbons (NMHC)

Table 1 indicates that national emissions of man-made non-methane hydrocarbons are approaching 1.8 million tonnes annually. Transportation accounts for 43% of this total (on-road 41%, off-road 3%). Other major sources are the motor fuel production, distribution, and marketing systems(9% of national total), industrial processes (gas plants, coal production, petrochemicals, plastics, and kraft pulping) at 11% of national emissions, and the use of industrial engines (5% of national total).

b) Carbon Monoxide (CO)

Table 1 indicates that transportation plays a major role in national emissions of CO, accounting for about 57% of total national emissions (on-road 55%, off-road 2%), while the use of industrial engines accounts for about 10% of total national emissions.

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c) Carbon Dioxide (CO_2)

National emissions of CO_2 from fossil fuels have exceeded 435 million tonnes annually as shown in Table 1. Transportation is the largest source at about 119 million tonnes annually (27% of national total) of which 98 million tonnes comes from on-road vehicles (23% of national total) and 21 million tonnes (5% of national total) from off-road transportation.

Among other major sources are thermal power generation (94 million tonnes or 22% of national total) and industrial fuel combustion (70 million tonnes annually or 16% of total national emissions).

d) Oxides of Nitrogen (NO_x)

Table 1 indicates that annual emissions of man-made NO_x exceed 1.9 million tonnes. The emissions are due primarily to the combustion of fuel in stationary sources and in mobile sources. The transportation category contributes about 1 million tonnes or 51% of the national total while fuel combustion in stationary sources contributes about 0.7 million tonnes or 36% of the national total. Industrial engines contribute 258 thousand tonnes or 13% of the national total.

e) Particulate Matter (PM)

Total annual emissions of particulates from all sources are about 2.2 million tonnes. Although the contribution of diesel particulates to this total from transportation and the industrial use of engines is small at 29 and 23 thousand tonnes respectively, the carcinogenic nature and inhalable size of these particulates is of concern.

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TABLE: 1 **EMISSION INVENTORIES (1985, KILOTONNES)**

SOURCE	HC[1]	CO	CO_2[2]	NO_x	PM[3]
TRANSPORTATION					
ON-ROAD					
Motorcycles (MC)	4.4	14.8	192	1.0	
Passenger Cars (PC)	470.7	4015.5	52,547	392.0	
Light-duty Gasoline Trucks (LDGT)	115.1	849.7	10,509	74.0	
Light-duty Diesel Trucks (LDDT)					
Medium-duty Gasoline Trucks (MDGT)	76.7	566.5	7,006	49.3	
Medium-duty Diesel Trucks (MDDT)	1.4	3.4	807	4.3	1.2
Heavy-duty Gasoline Vehicles (HDGV)	29.2	335.2	4,063	25.0	
Heavy-duty Diesel Vehicles (HDDV)	34.4	100.3	23,012	260.7	21.8
Total On-Road	731.9	5885.4	98,136	806.3	23.0
% of National	**41**	**55**	**23**	**41**	**NA**
OFF-ROAD					
Air	10.2	116.6	12,271	33.5	
Marine	27.9	84.9	5,219	16.7	
Rail	10.2	48.2	3,145	137.8	5.6
Total Off-Road	48.3	249.7	20,635	188.0	5.6
% of National	**3**	**2**	**5**	**10**	**NA**
Total Transportation	780.2	6135.1	118,771	994.3	28.6
% of National	**43**	**57**	**27**	**51**	**NA**
INDUSTRIAL ENGINES[4]					
Diesel	23.4	69.6	14,092	230.3	23.0
Gasoline	66.0	958.8	3,964	28.2	
Other	0.6				
FUEL					
Production, Distribution, Marketing	164.0	61.6			
FUEL COMBUSTION					
Residential	2.7	16.4	38,124	37.4	
Commercial	1.3	6.9	21,221	25.9	
Industrial	49.5	560.6	70,467	278.2	
Other [5]	107.9	624.2	9,158	3.9	
POWER GENERATION	2.6	56.1	94,428	247.9	
INDUSTRIAL PROCESSES [6]	203.1	713.2	29,656	88.9	
MISCELLANEOUS [7]	396.6	1577.9	35,299	24.3	
NATIONAL TOTAL	1797.9	10,780	435,180	1,959.3	2,200[8]

1. non-methane 2. 1987 fossil fuel only 3. diesel 4. construction & agricultural equipment, and other off-road gasoline and diesel equipment 5. fuel wood 6. gas plants, coal production, petrochemicals, plastics, kraft pulping 7. surface coatings, dry cleaning, solvent use, slash burning, other. 8. total particulate matter from all sources

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9. EMISSION PROJECTIONS:

Forecasts of future Canadian emissions should be viewed as an indication of trends only. Where there is some uncertainty over current inventories, there is greater uncertainty when the current inventories are projected into the future. Data on future emissions of some pollutants were not available for all sectors. The on-road transportation data is relatively complete. It is intended that the accuracy of emission inventories and forecasts will be improved as a part of this plan.

Some of the forecast data has been prepared to support federal involvement in international protocols on the environment (NO_x and VOCs); as input into ongoing OECD analyses; and to support the development of a federal/provincial action plan on NO_x and VOC controls. As with the emission inventories, the data are calculated from input from federal and provincial sources.

Forecasts were based on the following major assumptions:

- status quo emission controls - current vehicle standards and low NO_x burners on new power plants are included.
- National Energy Board (NEB) estimates have been used for car and truck stock growth rates.
- NEB estimates were used for fuel consumption in all sectors by fuel type.
- Informetrica economic and population growth estimates were used for other sources (by sector).
- Electricity growth rates and fuel mixes were used to forecast emissions for power plants.

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a) Non-Methane Hydrocarbons (NMHC)

Total national NMHC emissions are expected to increase by about 134,400 kg over 1985 levels in the next 20 years. Higher emissions in all sectors other than on-road motor vehicles account for the increase. Over the same period, NMHC emissions from on-road vehicles will decline by 278,600 kg. These reductions stem from new standards under the Motor Vehicle Safety Act brought in in 1987 for light-duty motor vehicles and in 1988 for heavy-duty motor vehicles.

Forecasts by major source are summarized in Table 2.

b) Carbon Monoxide (CO)

Reliable data for CO forecasts were not available for sources other than on-road motor vehicles. Projections for this sector are summarized in Table 3.

CO emissions from on-road vehicles are expected to decline by 1.8 million tonnes between 1985 and 2005 as a result of tighter standards implemented in 1987 and 1988 for light-duty and heavy-duty vehicles respectively. This represents a reduction of 30% over 1985 emission rates. The trend for total national CO emissions over the same period is unknown.

c) Carbon Dioxide (CO_2)

Rough estimates of emissions from the transportation sector for the year 2005 were made based on two NEB scenarios for fuel use - a high price and a low price scenario. The high price scenario is based on a 3 percent annual growth in the global economy which results in higher energy prices due to increased demand. The low price scenario is based on a 2% annual growth in the global economy which results in lower demand for energy and consequently lower prices. The higher price of energy in the high growth scenario tends to dampen energy demand and results in more investment in new more efficient capital equipment. The difference in fuel demand for transportation is small because of the relatively short time frame of the projections.

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Forecasts are summarized in Table 4. For the transportation sector, CO_2 emissions may increase by up to 30.3 million tonnes (24.5 million tonnes for on-road vehicles and 5.8 million tonnes for off-road transportation).

d) Oxides of Nitrogen (NO_x)

National NO_x trends to the year 2005 are broken down by major source for selected years in Table 5.

Despite control actions taken to date primarily with respect to mobile sources, NO_x emissions will increase with time to the extent that total national emissions in 2005 will be about 467,000 tonnes (24%) higher than current levels. Greater emissions from all sources except on-road motor vehicles account for these increases with power generation being the most significant.

e) Particulate Matter

Data for sources other than on-road diesel powered motor vehicles were not available.

For road diesels, particulate emissions are expected to decline as a result of new standards introduced in 1987 (light-duty) and 1988 (heavy-duty). The forecasts are summarized in Table 6.

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TABLE: 2 **NON-METHANE HYDROCARBON EMISSION PROJECTIONS**
1985 - 2005 (KILOTONNES)

SOURCE	1985	1990	1995	2000	2005
TRANSPORTATION					
ON-ROAD					
Motorcycles	4.4	5.0	5.5	6.1	6.7
Passenger Cars	470.7	404.4	307.8	271.4	271.1
LDGT	115.1	107.6	87.1	74.9	69.7
LDDT					
MDGT	76.7	71.8	58.1	50.0	46.5
MDDT	1.4	0.9	1.1	1.4	1.7
HDGV	29.2	26.9	22.1	22.2	24.0
HDDV	34.4	29.9	28.5	30.5	33.6
Total On-Road	731.9	646.5	510.2	456.5	453.3
% of National	41	36	29	25	23
OFF-ROAD					
Air	10.2	17.9	19.6	21.3	23.2
Marine	27.9	18.7	20.4	22.7	25.7
Rail	10.2	11.6	12.3	13.3	14.1
Total Off-Road	48.3	48.2	52.3	57.3	63.0
% of National	3	3	3	3	3
Total Transportation	780.2	694.7	562.5	513.8	516.3
% of National	43	39	32	28	27
INDUSTRIAL ENGINES[1]					
Gasoline	66.0	48.1	50.0	53.0	55.7
Diesel	24.0	41.6	45.1	49.1	54.6
Total Industrial Engines	90.0	89.7	95.1	102.1	110.3
% of National	5	5	5	6	6
FUEL [2]	164.0	170.7	191.1	212.6	223.4
FUEL COMBUSTION					
Residential/Commercial	4.0	3.8	3.7	3.9	4.2
Industrial	49.5	48.8	52.8	56.9	61.9
Fuel Wood	107.9	115.7	121.4	128.3	136.3
POWER GENERATION	2.6	2.8	2.8	2.8	2.8
INDUSTRIAL PROCESSES	203.1	233.9	270.2	312.4	366.1
MISCELLANEOUS	396.6	436.3	462.5	486.8	511.0
NATIONAL TOTAL	1797.9	1796.4	1762.1	1819.6	1932.3

1. Includes construction equipment, agricultural equipment, and other industrial equipment.2. Production, distribution, marketing.

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TABLE: 3 **CARBON MONOXIDE EMISSION PROJECTIONS 1985 - 2005 (KILOTONNES)**

SOURCE	1985	1990	1995	2000	2005
TRANSPORTATION					
ON-ROAD					
Motorcycles	14.8	16.9	18.6	20.4	22.4
Passenger Cars	4015.5	3507.9	2831.7	2616.2	2688.4
LDGT	849.7	843.4	725.6	667.3	656.1
LDDT					
MDGT	566.5	562.3	483.7	444.9	437.4
MDDT	3.4	2.8	3.2	3.6	4.1
HDGV	335.2	343.1	204.0	160.9	160.8
HDDV	100.3	110.9	117.5	128.0	142.1
Total On-Road	5885.4	5387.3	4384.3	4041.3	4111.3
% of National	55	NE[1]	NE	NE	NE
OFF-ROAD					
Air	116.6	NE	NE	NE	NE
Marine	84.9	NE	NE	NE	NE
Rail	48.2	NE	NE	NE	NE
Total Off-Road	249.7	NE	NE	NE	NE
% of National	2	NE	NE	NE	NE
Total Transportation	6135.1	NE	NE	NE	NE
% of National	57	NE	NE	NE	NE
INDUSTRIAL ENGINES					
Gasoline	958.8	NE	NE	NE	NE
Diesel	69.6	NE	NE	NE	NE
Total Industrial Engines	1028.4	NE	NE	NE	NE
% of National	10	NE	NE	NE	NE
STATIONARY SOURCES	3616.9	NE	NE	NE	NE
NATIONAL TOTAL	10,780	NE	NE	NE	NE

1. NE - not estimated

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TABLE: 4 CARBON DIOXIDE EMISSION PROJECTIONS
1987 - 2005 (KILOTONNES)

SOURCE	1987	2005 LOW	2005 HIGH
TRANSPORTATION			
ON-ROAD			
Motorcycles	192	219	222
Passenger Cars	52,547	58,498	59,283
LDGT	10,509	11,699	11,856
LDDT			
MDGT	7,006	7,799	7,904
MDDT	807	1,225	1,314
HDGV	4,063	4,523	4,584
HDDV	23,012	34,938	37,458
Total On-Road	98,136	118,901	122,621
% of National	23	NE[1]	NE
OFF-ROAD			
Air	12,271	14,454	15,659
Marine	5,219	6,541	6,332
Rail	3,145	4,277	4,487
Total Off-Road	20,635	25,272	26,478
% of National	5	NE	NE
Total Transportation	118,771	144,173	149,099
% of National	27	NE	NE
INDUSTRIAL ENGINES			
Diesel	14,092	21,395	22,938
Gasoline	3,964	4,413	4,472
Total Industrial Engines	18,056	25,808	27,410
% of National	4	NE	NE
FUEL			
Production, Distribution, Marketing		NE	NE
FUEL COMBUSTION			
Residential	38,124	NE	NE
Commercial	21,221	NE	NE
Industrial	70,467	NE	NE
Other	9,158	NE	NE
POWER GENERATION	94,428	NE	NE
INDUSTRIAL PROCESSES	29,656	NE	NE
MISCELLANEOUS	35,299	NE	NE
NATIONAL TOTAL	435,180	NE	NE

1. NE - Not Estimated

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TABLE: 5 OXIDES OF NITROGEN EMISSION PROJECTIONS
1985 - 2005 (KILOTONNES)

SECTOR	1985	1990	1995	2000	2005
TRANSPORTATION					
ON ROAD					
Motorcycles	1.0	1.2	1.3	1.5	1.6
Passenger Cars	392.0	346.0	272.1	253.7	269.4
LDGT	123.3	135.4	135.4	122.1	113.2
LDDT	4.3	3.6	3.6	4.0	4.6
HDGV	25.0	31.9	36.3	40.6	45.3
HDDV	260.7	227.0	214.5	227.6	252.5
Total On-Road	806.3	745.1	663.2	649.5	686.6
% of National	41	38	33	30	28
OFF-ROAD					
Air	33.5	42.3	46.4	50.3	54.7
Marine	16.7	17.1	18.6	20.7	23.7
Rail	137.8	118.0	126.5	136.3	145.3
Total Off-Road	188.0	177.4	191.5	207.3	223.7
% of National	10	9	10	10	9
Total Transportation	994.3	922.5	854.7	856.8	910.3
% of National	51	47	43	39	38
INDUSTRIAL ENGINES					
Diesel	230.3	276.2	300.2	329.4	369.7
Gasoline	28.2	26.2	26.8	28.3	29.8
FUEL COMBUSTION					
Residential	37.4	43.0	42.3	42.8	43.9
Commercial	25.9	31.7	32.5	33.6	36.8
Industrial	282.1	288.5	317.2	340.3	367.0
POWER GENERATION	247.9	226.3	278.2	370.9	482.4
INDUSTRIAL PROCESSES	88.9	103.7	122.0	137.0	152.7
INCINERATION/MISCELLANEOUS	24.3	26.4	28.6	31.1	33.7
NATIONAL TOTAL	1959.3	1944.5	2002.5	2170.2	2426.3

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TABLE: 6 **ON-ROAD DIESEL PARTICULATE EMISSION PROJECTIONS**

1985 - 2005 (KILOTONNES)

SOURCE	1985	1990	1995	2000	2005
MDDT	1.2	1.0	0.8	0.9	1.0
HDDV	21.8	22.6	14.1	11.4	11.6
TOTAL	23.0	23.6	14.9	12.3	12.6

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10. DESCRIPTION OF INITIATIVES UNDER STUDY:

Emission reduction opportunities possible in the mid 1990s were identified by applying the concept of BATEA to certain sources which contribute to emission inventories in Canada.

This plan will focus on four broad categories of emission sources: on-road vehicles, off-road applications, industrial engines, and motor fuels.

The first category of emission sources to be studied, on-road vehicles, includes those vehicles that may presently be regulated under the Motor Vehicle Safety Act (MVSA). This category includes motorcycles, light-duty vehicles, light-duty trucks, medium-duty vehicles and heavy-duty vehicles.

The second category to be examined for feasibility of achieving emission reductions is the off-road transportation sector which consists of aircraft, marine vessels and railway locomotives. This sector is not regulated under the MVSA or CEPA.

The third category is the industrial engine category. Industrial engines are those used in construction, agricultural and material handling equipment, as well as other industrial engine applications. At present these vehicles and engines are also not regulated under the MVSA or CEPA.

Finally, emission reductions possible from changes in motor fuel specifications and control of fugitive emissions from motor fuel production, distribution, marketing and use, will be considered under the authority of the Canadian Environmental Protection Act.

10.1 On-Road Vehicles

a) Exhaust and Evaporative Emissions

The use of BATEA will be investigated for all presently regulated vehicle classes and motorcycles. In addition, the control of emissions would be extended to vehicles powered by engines using alternative fuels. The

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objective of this extension would be to create a level playing field for all fuels while at the same time addressing concerns associated with characteristics particular to each fuel. Opportunities to reduce carbon dioxide emissions from all vehicle classes are also included in this plan. Emission levels thought to be possible in the mid 1990s using BATEA are summarized in the following tables.

TABLE: 7 **MOTORCYCLE EMISSION LEVELS[1]**

	Exhaust Emissions (g/mile)					Evap. HC or OMHCE[2] (g/test)
	HC or OMHCE[2]	CO	NO_x	HCHO[3]	CO_2	
Current	-	-	-	-	-	-
Proposed	0.25[4]	3.4	0.40	0.015	TBD[5]	2.0

1) In addition to the levels above, no crankcase emissions are allowed.

2) The HC level applies to non-oxygenated hydrocarbon fuelled motorcycles while the Organic Material Hydrocarbon Equivalent (OMHCE) level applies to oxygenated-fuelled motorcycles.

3) Formaldehyde.

4) Non-methane hydrocarbons.

5) To be determined.

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TABLE: 8 **LIGHT-DUTY VEHICLE EMISSION LEVELS[1]**

	Exhaust Emissions (g/mile)						Evap. HC or OMHCE[2] (g/test)
	HC or OMHCE[2]	CO	NO_x	PM	CO_2	HCHO[6]	
Current	0.41	3.4	1.0	0.20	-	-	2.0
Proposed	0.25[3]	3.4	0.40	0.08	320[4] 250[5]	0.015	2.0

1) In addition to the levels above, no crankcase emissions are allowed.

2) The HC level applies to non-oxygenated hydrocarbon fuelled vehicles while the Organic Material Hydrocarbon Equivalent (OMHCE) level applies to oxygenated-fuelled vehicles.

3) Non-methane hydrocarbons.

4) This level may be met on an individual vehicle or company average basis.

5) This level may be met on an individual vehicle or company average basis and applies to the 2005 and later model years.

6) Formaldehyde.

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TABLE: 9 **LIGHT-DUTY TRUCK EMISSION LEVELS[1]**

(Gross Vehicle Weight Rating: ≤ 6000 lbs)

	Loaded Vehicle Weight (lbs.)	Exhaust Emissions (g/mile)						Evap. HC or OMHCE[2] (g/test)
		HC or OMHCE[2]	CO	NO_x	PM	CO_2	HCHO[8]	
Current	≤ 3750	0.80	10	1.2	0.26	-	-	2.0
	> 3750	0.80	10	1.7	0.26	-	-	2.0
Proposed	≤ 3750	0.25[3]	3.4	0.4	0.08	400[4], 320[5]	0.015	2.0
	3751-5750	0.32[3]	4.4	1.0	0.08	460[6], 360[7]	0.018	2.0

1) In addition to the levels above, no crankcase emissions are allowed and CO emissions shall not exceed 0.50% of exhaust gas flow at curb idle.

2) The HC level applies to non-oxygenated hydrocarbon fuelled vehicles while the Organic Material Hydrocarbon Equivalent (OMHCE) level applies to oxygenated-fuelled vehicles.

3) Non-methane hydrocarbons.

4) This level applies to all 2-wheel drive light-duty trucks regardless of loaded vehicle weight and may be met on an individual vehicle or company average basis.

5) This level applies to all 2-wheel drive light-duty trucks regardless of loaded vehicle weight and may be met on an individual vehicle or company average basis. This level applies to the 2005 and later model years.

6) This level applies to all 4-wheel drive light-duty trucks regardless of loaded vehicle weight and may be met on an individual vehicle or company average basis.

7) This level applies to all 4-wheel drive light-duty trucks regardless of loaded vehicle weight and may be met on an individual vehicle or company average basis. This level applies to the 2005 and later model years.

8) Formaldehyde.

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TABLE: 10 **MEDIUM-DUTY VEHICLE EMISSION LEVELS[1]**

(Gross Vehicle Weight Rating: 6001 - 8500 lbs)

	Loaded Vehicle Weight (lbs.)	Exhaust Emissions (g/mile)						Evap. HC or OMHCE[2] (g/test)
		HC or OMHCE[2]	CO	NO_x	PM	CO_2	HCHO[8]	
Current LDT	≤ 3750	0.80	10	1.2	0.26	-	-	2.0
	> 3750	0.80	10	1.7	0.26	-	-	2.0
Proposed	≤ 3750	0.25[3]	3.4	0.4	0.08	400[4] 320[5] 460[6] 360[7]	0.015	2.0
	3751-5750	0.32[3]	4.4	1.0	0.08		0.018	2.0
	> 5750	0.50[3]	9.0	1.5	0.08		0.018	2.0

1) In addition to the levels above, no crankcase emissions are allowed and CO emissions shall not exceed 0.50% of exhaust gas flow at curb idle.

2) The HC level applies to non-oxygenated hydrocarbon fuelled vehicles while the Organic Material Hydrocarbon Equivalent (OMHCE) level applies to oxygenated-fuelled vehicles.

3) Non-methane hydrocarbons.

4) This level applies to all 2-wheel drive medium-duty vehicles regardless of loaded vehicle weight and may be met on an individual vehicle or company average basis in combination with light-duty trucks.

5) This level applies to all 2-wheel drive medium-duty vehicles regardless of loaded vehicle weight and may be met on an individual vehicle or company average basis in combination with light-duty trucks. This level applies to the 2005 and later model years.

6) This level applies to all 4-wheel drive medium-duty vehicles regardless of loaded vehicle weight and may be met on an individual vehicle or company average basis in combination with light-duty trucks.

7) This level applies to all 4-wheel drive medium-duty vehicles regardless of loaded vehicle weight and may be met on an individual vehicle or company average basis in combination with light-duty trucks. This level applies to the 2005 and later model years.

8) Formaldehyde.

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TABLE: 11 **HEAVY-DUTY VEHICLE EMISSION LEVELS[1]**

(Gross Vehicle Weight Rating: > 8500 lbs)

	Gross Vehicle Weight (lbs.)	Exhaust Emissions (g/bhp-hr)						Evap. HC or OMHCE[2] (g/test)
		HC or OMHCE[2]	CO	CO_2	NO_x	PM	HCHO[6]	
Current	≤ 14,000	$\frac{1.1^3}{1.3^4}$	$\frac{14.4^3}{15.5^4}$	-	6.0	0.60[4]	-	3.0
	> 14,000	$\frac{1.9^3}{1.3^4}$	$\frac{37.1^3}{15.5^4}$					4.0
Proposed	> 8,500	$\frac{1.1^3}{1.3^4}$	$\frac{14.4^3}{15.5^4}$	TBD[5]	5.0	0.10	0.05	2.0

1) In addition to the levels above, no crankcase emissions are allowed and CO emissions shall not exceed 0.50% of exhaust gas flow at curb idle.

2) The HC standard applies to non-oxygenated hydrocarbon fuelled vehicles while the Organic Material Hydrocarbon Equivalent (OMHCE) level applies to oxygenated-fuelled vehicles.

3) Applies to Otto-cycle heavy-duty vehicles.

4) Applies to Diesel-cycle heavy-duty vehicles.

5) To be determined.

6) Formaldehyde.

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In addition to the exhaust and evaporative emission levels noted, measures to reduce in-use, refuelling and running loss emissions from on-road motor vehicles will be investigated. The plan will focus on the following areas:

b) In-Use Emissions

- adoption of emission control component labels and hose routing diagrams;
- adoption of emission control component warranties for the useful life of all vehicles;
- adoption of on-board emission control system diagnostics; and
- assessment of inspection and maintenance programs and preparation of an implementation guideline.

These measures will primarily assist the provinces in adopting programs to control emissions from vehicles in use within a province.

c) Vehicle Refuelling Emissions

- Refuelling vapour recovery using systems on-board the vehicle will be studied for all vehicle classes to determine feasible levels of control.

d) Running Loss Emissions

- Running loss emission controls will be studied for all vehicle classes to determine feasible levels of control.

This list of emission reduction opportunities is not necessarily complete. Other measures may be investigated depending on technological developments over the next few years.

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10.2 Industrial Engines

As discussed earlier, industrial engines include those used in construction and agricultural equipment as well as those used for other industrial applications. Most emission control technologies developed for on-road vehicles should be adaptable to industrial engines.

Industrial engine emissions have not been regulated in Canada in all cases. Presently industrial engines emit considerably higher levels of pollutants per unit of work than their on-road counterparts. Consequently, it is believed that the transfer of advanced emission control technology to industrial engines could allow these engines to achieve emission levels similar to those being studied for heavy-duty on-road vehicles. This would result in emission reductions ranging from 30% - 90% for the various pollutants. The investigation will focus on assessing the feasibility of achieving on-road levels of emission control for industrial engines while considering the limitations imposed by their different duty cycles, application requirements and operating conditions.

10.3 Off-Road Transportation Sector

Preliminary data indicates that emission reductions of between 60% - 70% could be achieved by applying advanced emission control technology to railway locomotives and between 38% - 71% reductions for marine vessels. These emission reductions assume emission levels comparable to those from heavy-duty on-road vehicles. The feasibility of adopting such levels for railway locomotives and marine vessels will be the focus of this investigation. In addition, the feasibility of adopting emission controls for aircraft engines will be addressed in the study.

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10.4 Motor Fuels

a) Gasoline

Gasoline properties and composition have an effect on the quantity and type of pollution being emitted when the fuel is burned in an engine. The effect of the following will be investigated:

- volatility
- aromatics content - Benzene
  Toluene
  Xylene
- additives

i) Gasoline Volatility

Gasoline volatility has an effect on evaporative and tailpipe emissions from motor vehicles and on losses during storage, transportation, and transfer of gasoline. Recent information on evaporative running losses from vehicles indicates that emissions are much higher than previously thought, particularly during hot weather typical of ozone episodes. The effect of gasoline volatility on the amount and type of hydrocarbon emissions will be studied as well as its effect on fuel consumption, safety and gasoline cost. The interaction of gasoline volatility and emission control equipment will also be examined.

ii) Aromatics

Benzene, toluene and xylene have been placed on the Priority Substances List pursuant to the Canadian Environmental Protection Act. Action taken to reduce these compounds in gasoline will depend in large part on the results of the evaluations being made under the Canadian Environmental Protection Act. The impacts of controlling the aromatic content of gasoline will be investigated under this plan.

iii) Additives

Besides their direct effect on human health, additives can have an effect on the performance of emission control devices. Lead content was limited in unleaded gasoline because of its effect on automotive catalytic converters. More recently, the lead content of leaded

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gasoline was reduced because of its effect on human health. Lead in gasoline will not be studied as a part of this plan because regulations to come into effect in 1990 will essentially eliminate lead emissions from mobile sources and prevent misfuelling of motor vehicles.

Methylcyclopentadienyl manganese tricarbonyl (MMT) is an octane enhancing additive used in all Canadian gasoline in concentrations up to 18 mgMn/l. The use of MMT in gasoline was reviewed as part of earlier studies done on the costs and benefits of adopting more stringent emission standards for light-duty vehicles because of its effect as a neurotoxin and because of its adverse effects on emission control devices and increased tailpipe HC emissions.

The use of MMT and other additives to motor fuels that may have a direct or indirect effect on health or the environment will be investigated.

The impact of the following changes to gasoline specifications will be studied.

	RVP[1]	Benzene	Toluene	Xylene	Aromatics	MMT[2]
Current	79-86	-	-	-	-	18
Proposed	62	0.6%[3]	TBD[4]	TBD[4]	TBD[4]	0

1. Reid Vapour Pressure, May to September, kPa
2. mgMn/l
3. by volume
4. to be determined

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b) Diesel Fuel

Diesel fuel properties have an effect on the quantity and type of pollution emitted from diesel engines. The effect of the following fuel properties will be investigated.

- Sulphur Content
- Cetane
- T90 Temperature
- Fuel Composition

This list is not necessarily complete. The effect of fuel properties on the emission characteristics of new technology and existing diesel engines will be evaluated as part of the overall effort to study opportunities to reduce emissions from mobile sources.

i) Sulphur Content

The sulphur content of diesel fuel affects the quantity of particulate emissions emitted by diesel engines. As particulate emissions from diesel engines are reduced, sulphur becomes a larger portion of total particulate emissions. Sulphur removal from diesel fuel may be necessary to achieve the low particulate emission levels being studied in this plan. Sulphur in diesel fuel may also prevent the use of some control technologies such as catalysts or may reduce the life expectancy of others such as particulate traps. The engine manufacturers and fuel producers in the United States have agreed that engines designed to meet stringent particulate emission standards will need fuel with less than 0.05% sulphur. If such vehicle standards are adopted in Canada, suitable fuels will have to be available. Sulphur removal will also reduce particulate emissions from existing engines. The benefits of reduced fuel sulphur content will also be evaluated for all existing uses.

Sulphur from diesel fuel and heavy fuel oil used in transportation accounts for only 2% of national SO_2 emissions. Sulphur reduction in diesel fuel is a strategy to control emissions of diesel particulates. Its effect on acid precipitation is small.

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ii) Cetane

Cetane number is a measure of the ignitability of diesel fuel. Cetane influences NO_x, HC, and particulate emissions. The cetane quality of future diesel fuels is expected to decline. The need to at least maintain, at current levels, or possibly improve cetane levels for future diesel engines will be investigated.

iii) T90

T90 is the temperature at which 90% of the diesel fuel is evaporated during a standard distillation test. High T90 can increase the soluble organic fraction of diesel particulate and therefore the mass of particulate emissions. High T90 can also increase engine deposits and reduce engine life. The need to specify a T90 temperature will be investigated.

iv) Fuel Composition

Fuel composition affects emissions and the durability of emission control hardware. Reducing diesel fuel aromatics would reduce the carbonaceous fraction of diesel particulate emissions. It is expected that reducing the aromatic content to 10% by volume would reduce particulate emissions by 25%. The need to control fuel composition (i.e. aromatics, sulphur, additives) and cleanliness will be examined.

Diesel fuel with the following properties will be assessed:

	Sulphur[1]			Cetane[3]			T90 (°C)			Aromatics[2]		
Fuel Type	AA	A	B	AA	A	B	AA	A	B	AA	A	B
Current	0.2	0.5	0.7	40	40	40	290	315	360	-	-	-
Proposed	0.05			≥ 40			TBD[4]			10		

1. % by weight
2. % by volume
3. minimum
4. to be determined

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c) Evaporative Emissions from Gasoline Marketing and Distribution

Gasoline has a high vapour pressure compared to other liquid transportation fuels. This high vapour pressure in combination with the large volume of gasoline used means that gasoline marketing and use accounts for a large proportion of the evaporative VOC emissions from the transportation sector. Evaporative emissions can be reduced by changing the composition of gasoline to reduce its vapour pressure; by preventing escape of vapour during storage and transfer of fuel between the refinery and retail stations; by capturing vapour during vehicle refuelling using systems on the vehicle and on the service station gasoline pump; and by requiring more effective vapour control systems on gasoline-powered motor vehicles and equipment.

Vapour recovery from fuel transfer operations is classed as Stage I and Stage II. Stage I involves recovering vapour during all transfer operations between the refinery and the gasoline service station. Stage II involves recovering vapour lost during vehicle refuelling using systems and equipment attached to the service station gasoline dispensing pumps as opposed to systems on-board the vehicle itself (ie. on-board controls).

i) Stage I Controls

The capture of vapours displaced during the refilling of underground tanks at service stations is accomplished by employing trucks fitted with a balanced unloading system. A partial vacuum is created above the liquid gasoline as it flows from the truck into the tanks of the gasoline station. Vapour from the station tank is thereby reintroduced into the truck through a separate vapour line. Vapours collected from the gasoline station storage tanks are then hauled by the returning truck to the bulk terminal. The air-vapour mixture displaced when the truck is refilled is sent to a vapour recovery unit which separates the hydrocarbons from the air. The gasoline vapour is liquified into gasoline. Similar vapour recovery procedures would apply to rail car and barge loading operations.

Bulk plants normally have low throughput. Storage tanks are relatively small and have fixed roofs. These storage tanks would have to incorporate vapour balancing during truck loading and unloading to reduce fugitive emissions.

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Permissible emissions from vapour recovery units in the United States vary from 80 mg/litre for retrofitted systems to 35 mg/litre of gasoline transferred in new facilities. Some areas of the United States require the more stringent level for all terminals. The 35 mg/litre level represents a recovery rate of approximately 96 percent of the vapours expelled from tanker trucks.

In addition to the installation of vapour recovery units at marketing terminals and modifications for bottom loading, vapour recovery requires a number of changes to trucks and service stations. Trucks used to haul gasoline are usually loaded from top hatches. To capture gasoline vapours, these hatches must be sealed and a vapour manifold system installed. Trucks must also be converted by installing extra valves to allow bottom loading. Bottom loading is safer because the truck driver does not have to climb on top of his truck to open hatches for refuelling and there are no openings to the atmosphere to allow combustible vapours to escape.

Experience in the United States has shown that an inspection and enforcement program is necessary for trucks with vapour recovery systems. Without an enforcement program, trucks develop vapour leaks which reduce the effectiveness of the systems.

The changes required at service stations for Stage I vapour recovery are relatively simple and can be retrofitted to most existing service station tanks.

ii) Stage II Controls

With Stage II control systems, vapours emitted from the vehicle's fuel tank during refuelling are returned to the service station's underground tank.

Stage II controls can only be installed where Stage I controls are in place. The vapour displaced during vehicle refuelling is captured and stored in the underground tank where it is recovered by Stage I control measures.

As part of this investigation of Stage I and Stage II vapour recovery, the effect of exemptions for low volume facilities, of regional versus national control, and of implementation schedules on cost and effectiveness will be assessed.

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d) Elimination of Propane Emissions During Refuelling of Fixed Tanks

The maximum fill level of propane tanks is fixed at 80% by safety regulations to allow for thermal expansion. Small portable tanks are filled by weight but large tanks including those used on motor vehicles use a spit valve to indicate the 80% full point. This spit valve is opened before the start of propane delivery and vents gaseous propane through a small orifice during the whole refuelling operation. When the liquid propane reaches the 80% full point, liquid propane begins to "spit" from the valve. The attendant then knows that the tank is 80% full and stops filling. The spit valve and fill valve are then closed.

Automatic shut-off devices have been developped that can eliminate the use of spit valves. Propane losses during refuelling will then be reduced as well as the danger of fire and explosion. The use of automatic shut-off valves will be investigated.

11. EMISSION REDUCTIONS:

The emission reductions were calculated using the MOBILE3C fleet emission factor program and fleet growth factors from the National Energy Board's 1984 forecast. Inventory numbers and projected emission reductions will be revised as newer projections from the NEB are incorporated into the inventory and as the MOBILE4C fleet emission factor program becomes available.

Preliminary estimates of the effect of adopting the various emission control measures included in this plan are detailed in Table 12. Based on data available at this time, estimates of reductions are limited to the on-road portion of the transportation sector and do not include the reductions possible from:

- improved diesel fuel quality
- control of fugitive emissions from gasoline production, distribution and marketing
- control of off-road transport emissions
- control of industrial engines
- reductions of running loss emissions.

Development of emission reduction possibilities from all of these categories is a part of this plan.

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Table 12 indicates that annual reductions in 2005 of 250 kilotonnes of HC, 1.0 million tonnes of CO, 119 kilotonnes of NO_x and 6 kilotonnes of particulate matter are possible from on-road vehicles as a result of implementing in 1997[1]:

- improved gasoline quality
- tighter exhaust and evaporative emission standards for all classes of on-road vehicles
- adoption of provincial in-use inspection and maintenance programs
- recovery of vehicle refuelling vapours using systems on-board the vehicle

The noted reductions represent savings of 34% HC, 18% CO, 15% NO_x and 28% particulate matter relative to the emissions from the on-road vehicle fleet in 1985.

Under this plan CO_2 emissions would be capped at current levels until 2005 at which time an improvement of 20% in the CO_2 performance of the new on-road vehicle fleet will be required. The initial capping of CO_2 emissions does represent an increased level of control of this pollutant in that CO_2 emissions would normally be expected to increase as a result of more stringent levels of control on HC, CO, NO_x and particulate emissions.

1. 1997 has been used as a date for modelling purposes only and should not be viewed as the date on which control actions would necessarily take effect.

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TABLE: 12

ON-ROAD MOTOR VEHICLES
ANNUAL EMISSION REDUCTIONS IN 2005[1]
(KILOTONNES)

VEHICLE CLASS	CONTROL[2] ACTION	HC	CO	CO_2	NO_x	PM
LDV	1 3 6 7	39.8[3] 49.4[5] 0-67.8[4] 20.6[6]	0-672.1[4]	NO GROWTH	82.9[5] 0-13.4[4]	
LDGT	1 4 6 7	7.7[3] 7.7[7] 0-17.4[4] 4.3[6]	50.0[7] 0-164.1[4]	NO GROWTH	9.1[7] 0-3.4[4]	
LDDT				NO GROWTH		
MDGT	1 5 6 7	5.1[3] 5.1[8] 0-11.6[4] 2.9[6]	30.4[8] 0-109.4[4]	NO GROWTH	5.4[8] 1-2.3[4]	
MDDT	5			NO GROWTH	1.4[11]	0.5[11]
HDGV	1 7	3.2[3] 1.7[6]		NO GROWTH		
HDDV	8			NO GROWTH		5.9[10]
MC	1 2	0.3[3] 5.4[9]	20.2[9]	NO GROWTH	1.1[9]	
TOTAL		250.0	1,046.2	N/A	119.0	6.4
% of 1985 On-Road Transport Emissions		34	18	N/A	15	28
% of 1985 Total National Emissions		14	10	N/A	6	NA

Refer to the footnotes on the following pages

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FOOTNOTES TO TABLE 12:

1. For modelling purposes only, assumes implementation of new standards or programs in 1997.

2. Listing of Control Actions follows:

Control Action	Description
1	Reduced gasoline volatility
2	More stringent motorcycle exhaust and evaporative emission standards
3	More stringent light-duty vehicle exhaust emission standards
4	More stringent light-duty truck exhaust emission standards
5	More stringent medium-duty vehicle exhaust emission standards
6	Implementation of in-use vehicle inspection and maintenance programs
7	On-board refuelling vapour recovery standards
8	More stringent heavy-duty vehicle exhaust emission standards

3. Mobile 3 has a fixed factor for evaporative emissions which is representative of evaporative emissions found with gasoline having 11.7 psi RVP under the standard Federal Test Procedure (FTP) conditions. The effect of lowering RVP during the summer was estimated using emission factors published in the draft RIA Control of Gasoline Volatility and Evaporative Hydrocarbon Emissions from New Motor Vehicles published by the EPA in July 1987. Uncontrolled Diurnal Indices (UDI) were calculated using the computer program published in the

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RIA for a number of Canadian cities for typical summer temperatures. These were used to calculate emissions for different fuel volatilities. The numbers presented are annualized reductions that would be achieved if RVP were limited to 9.0 psi from May to September.

4. These numbers represent the range of emission reductions achievable by inspection and maintenance programs. Emission reductions of up to 25% were assumed for HC and CO and 5% for NO_x for all gasoline-powered light-duty vehicles and light trucks. Precise estimates cannot be made unless exact details for the I&M program design are available. The Federal initiatives will of themselves reduce emissions from in-use vehicles, but provincial I&M programs will greatly enhance the effect of these measures.

5. These numbers represent the effect of adopting the proposed emission levels for light-duty vehicles effective in the 1997 model year. Since no OEM vehicles now use gaseous fuel or methanol and diesel vehicles represent a very small fraction of all new vehicle sales of this type in Canada, the emissions reductions given are based on a fleet of gasoline-powered light-duty vehicles. To calculate the benefits of lower standards, the base emission rate was reduced proportionately to the change in standard for each pollutant. The deterioration rate was then adjusted to yield a proportional reduction in the 50,000 mile emission rate.

6. The benefit of on-board vapour recovery was calculated on a % control of refueling vapours as calculated in the emissions inventory. EPA has published a graph with % control of refueling vapour emissions versus the number of years after the introduction of on-board controls. The emissions reduction was apportioned over the different types of vehicles based on the percentage of fuel used by each type.

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7. These numbers represent the effect of adopting the proposed emission levels for light-duty trucks up to 6,000 lbs GVWR effective with the 1997 model year. Since no OEM vehicles now use gaseous fuels or methanol, and diesel vehicles represent a very small fraction of all new vehicle sales of this type in Canada, the emissions reduction given are based on a fleet of gasoline-powered light-duty trucks. Since two different standards apply, depending on the loaded vehicle weight, it was assumed that half the trucks meet the more stringent standard, so that the effective standard is the average of the two. This is a conservative estimate since 60% to 75% of LDT's have a loaded vehicle weight below 3750 lbs. To calculate the benefits of lower standards, the base emission rate was reduced proportionately to the change in standard for each pollutant. However, the "standard" deterioration rates for light-duty trucks are approximately half those of light-duty vehicles and these were not changed to produce a proportional reduction in the 50,000 mile emission rate since the resultant deterioration rates would have been overly optimistic.

8. The calculated reductions in emissions from adopting the proposed emission levels for medium-duty trucks are the same as for light-duty trucks except that diesels were treated separately from gasoline-powered trucks. A number of possible standards apply depending on the loaded vehicles weight. It was assumed that all medium-duty trucks have a loaded vehicle weight over 3750 lbs. and that none have a loaded vehicle weight above 5750 lbs.

9. There is no reliable data available on the emission performance of Canadian motorcycles. The Mobile3 emission factors for the 1978-1979 model years were used for Canadian motorcycles from 1978 onward. The emission reductions were calculated from this base.

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10. The proposed standards for heavy-duty engines are the same as the present Canadian standard except for NO_x which changes from 6.0 g/bhp-hr. to 5 g/bhp-hr. and for particulates which change from 0.6 to 0.1 g/bhp-hr. No benefit is claimed for the lower NO_x standard since it is assumed that Canada would get engines meeting the 5.0 g/bhp-hr and 0.25 g/bhp-hr U.S. NO_x and particulate standards beginning in 1991. It was assumed that engines would continue to meet the 0.25 g/bhp-hr. standard in Canada after the U.S. standard is reduced to 0.10 g/bhp-hr. in 1994. These are the base case assumptions. Reductions due to tighter standards were calculated from this base.

11. The base NO_x emission rate was assumed to be 0.75 g/mi. and the deterioration rate was not changed from Mobile 3. Particulate emission rates were estimated using the EPA's particulate program.

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12. ANALYSIS METHODOLOGY:

The study of each of the initiatives under consideration will follow a standardized approach, where appropriate, in keeping with current regulatory impact analysis requirements. This will include the analysis of technical, environmental, economic, and social factors associated with each initiative.

Consultation with all interested parties to solicit and secure their opinions and data related to the plan is an important element of the information gathering process.

13. SCHEDULE:

The schedule for completion of the work outlined in this plan will extend over a number of years.

Initially, work will be undertaken to identify the availability and impacts of technology and management practices that can reduce emissions from the sectors under study. These analyses can then be used to support decisions respecting which emission control options are feasible and desirable for implementation. These steps are expected to be completed before 1991. Proposals for control regulations would then be made, formal consultation undertaken and standards, where appropriate, would begin coming into effect in the mid 1990s.

14. CONSULTATIONS:

A public meeting will be held in Ottawa in the auditorium of the National Archives of Canada, 395 Wellington St. on September 18-22, 1989. Daily sessions will commence at 9:00 am.

All interested parties are invited to attend the meeting and are encouraged to present their views on the plan and any information or data that would be helpful to the Government in completing the work covered by the plan.

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Those wishing to present briefs at the referenced meetings should contact:

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by August 31, 1989 so that scheduling arrangements can be completed.